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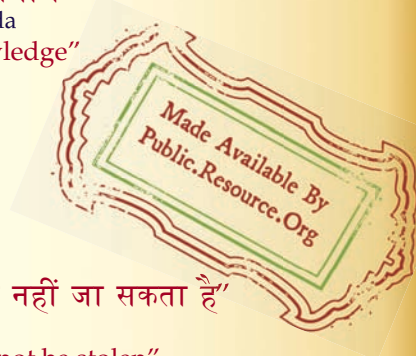
IS 9735 (2003): Electrical Apparatus for Explosive Gas Atmospheres - Flameproof Enclosures 'd' - Method of Test for Ascertainment of Maximum Experimental Safe Gap [ETD 22: Electrical Apparatus for Explosive Atmosphere]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक

विस्फोटक गैस वातावरण के लिए विद्युत उपकरण—
ज्वालासह आवेष्टन “d” — अधिकतम प्रायोगिक सुरक्षित
स्थान ज्ञात करने की परीक्षण पद्धति
(पहला पुनरीक्षण)

Indian Standard

ELECTRICAL APPARATUS FOR EXPLOSIVE
GAS ATMOSPHERES—FLMAEPROOF ENCLOSURES
“d” —METHOD OF TEST FOR ASCERTAINMENT
OF MAXIMUM EXPERIMENTAL SAFE GAP
(*First Revision*)

ICS 29.260.20

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NEW DELHI 110002

NATIONAL FOREWORD

This Indian Standard (First Revision) which is identical with IEC 60079-1-1(2002) 'Electrical apparatus for explosive gas atmospheres — Part 1-1 : Flameproof enclosures "d" — Method of test for ascertainment of maximum experimental safe gap' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendations of the Electrical Apparatus for Explosive Atmospheres Sectional Committee and approval of the Electrotechnical Division Council.

This standard was first issued in 1981. The first revision of this standard has been undertaken to align it with corresponding IEC Standard.

The text of the IEC Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

- a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
- b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Only the English text of the International Standard has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding of numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRICAL APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES—FLMAEPROOF ENCLOSURES “d”—METHOD OF TEST FOR ASCERTAINMENT OF MAXIMUM EXPERIMENTAL SAFE GAP (*First Revision*)

1 Scope

This part of IEC 60079 describes a test method intended for the measurement of the maximum experimental safe gaps for gas- or vapour-air mixtures under normal conditions of temperature¹ and pressure so as to permit the selection of an appropriate group of flameproof enclosures.

The method does not take into account the possible effects of obstacles on the safe gaps².

2 Definitions

For the purpose of this part of IEC 60079, the following definitions apply.

2.1 maximum experimental safe gap

MESG

maximum gap between the two parts of the interior chamber which, under the test conditions specified below, prevents ignition of the external gas mixture through a 25 mm long flame path when the internal mixture is ignited, for all concentrations of the tested gas or vapour in air

3 Outline of method

The interior and exterior chambers of the test apparatus are filled with a known mixture of the gas or vapour in air, under normal conditions of temperature³ and pressure (20 °C, 10⁵ N/m²) and with the circumferential gap between the two chambers accurately adjusted to the desired value. The internal mixture is ignited and the flame propagation, if any, is observed through the windows in the external chamber. The maximum experimental safe gap for the

¹ An exception if made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 °C above that needed to give the necessary vapour pressure is used.

² The design of the test apparatus for safe gap determination, other than that used for selecting the appropriate group of enclosure for a particular gas, may need to be different to the one described in this standard. For example, the volume of the enclosure, flange width, gas concentrations and the distance between the flanges and any external wall or obstruction may have to be varied. As the design depends on the particular investigation which is to be undertaken, it is unpracticable to recommend specific design requirements, but for most applications the general principles and precautions indicated in the clauses of this standard will still apply.

³ An exception is made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 °C above that needed to give the necessary vapour pressure is used.

gas or vapour is determined by adjusting the gap in small steps to find the maximum value of gap which prevents ignition of the external mixture, for any concentration of the gas or vapour in air.

4 Test apparatus

The apparatus is described in the following subclauses and is shown schematically in figure 1.

4.1 Mechanical strength

The whole apparatus is constructed to withstand a maximum pressure of 15×10^5 N/m² without significant expansion of the gap, so that no such expansion of the gap will occur during an explosion.

4.2 Interior chamber

The interior chamber "a" is a sphere with a volume measuring 20 cm³.

4.3 Exterior chamber

The exterior cylindrical enclosure "b" has a diameter of 200 mm and a height of 75 mm.

4.4 Gap adjustment

The two parts "k" and "l" of the internal chamber are so arranged that an adjustable 25 mm gap can be set up between the plane parallel faces of the opposing rims. Part "l" is pressed upwards against the micrometer screw by a strong spring "c". The exact width of the gap can be adjusted by means of the micrometer and its value measured by the scale engraved on the micrometer head. The micrometer screw has a diameter of 16 mm and a thread pitch of 0,5 mm.

4.5 Injection of mixture

The internal chamber is filled with the gas- or vapour-air mixture through a hole measuring 3 mm in diameter. The dead volume of the channels to this inlet is 5 cm³. The inlet to the external chamber consists of seven holes each 2 mm in diameter. The inlet and outlet are protected by flame arresters "e".

4.6 Source of ignition

A 3 mm spark-gap with stainless steel electrodes is placed 14 mm from the inner edge of the flange gap. The electrodes should be mounted in such a way that the spark path is perpendicular to the plane of the joint and should be symmetrically placed on both sides of the plane.

4.7 Observation windows

Two circular observation windows "f" with an overall diameter of 74 mm are fitted to opposite sides of the external enclosure.

4.8 Materials of test apparatus

The main parts of the test apparatus, and in particular the walls and flanges of the inner chamber and the electrodes of the spark-gap "h", are normally of stainless steel. Other materials may have to be used with some gases or vapours, however, in order to avoid corrosion or other chemical affects. Light alloys should not be used for the spark-gap electrodes.

5 Procedure

5.1 Preparation of gas mixtures

As the constancy of the mixture concentration, for a particular test series, has a pronounced effect on the dispersion of the test results, it has to be carefully controlled.

The flow of the mixture through the chamber is therefore maintained until the inlet and outlet concentrations are the same, or a method of equivalent reliability must be used.

The moisture content of the air used for the preparation of the mixture should not exceed 0,2 % by volume (10 % relative humidity).

5.2 Temperature and pressure

The tests are made at an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, except where otherwise permitted⁴. The pressure within the test apparatus is adjusted to 10^5 N/m^2 by means of the pump "d".

5.3 Gap adjustment

The gap is first reduced to a very small value and examined through the observation windows to ensure that the flanges are parallel. The zero setting of the gap is checked but the value of torque applied should be low (e.g. a force of about 10^{-2} N applied at the circumference of the micrometer head).

5.4 Ignition

The internal mixture is ignited by means of the spark-gap in the internal chamber, with a normal automobile ignition coil for the voltage supply.

5.5 Observation of the ignition process

Ignition of the internal mixture is confirmed by observation through the gap when the test is made. If no internal ignition occurs, the test is invalid. Ignition of the mixture in the external chamber is taken to occur when the whole volume of the chamber is seen to be filled by the flame of the explosion.

6 Determination of maximum experimental safe gap

6.1 Preliminary tests

With a defined mixture of the combustible vapour or gas with air, two ignition tests are carried out on a number of gaps, at 0,02 mm intervals, covering the range from a safe gap to an unsafe gap. From the results, the highest gap, g_0 , at which there is 0 % probability of ignition, and the lowest gap, g_{100} , giving 100 % probability of ignition, are determined.

The test series is repeated with a range of mixture concentrations, and the variation of the gap g_0 and g_{100} are obtained. The most dangerous mixture is that for which these values are a minimum.

⁴ An exception is made for substances with vapour pressures which are too low to permit mixtures of the required concentrations to be prepared at normal ambient temperatures. For these substances, a temperature 5 °C above that needed to give the necessary vapour pressure is used.

6.2 Confirmatory tests

The results are confirmed by repeating the tests, with 10 explosion tests for each step of gap adjustment, at a number of concentrations in the neighbourhood of the most dangerous mixture found in the preliminary series. The minimum values of g_0 and g_{100} are then determined.

6.3 Reproducibility of maximum experimental safe gaps

The highest acceptable difference between the values of $(g_0)_{\min}$ obtained from different test series is 0,04 mm.

If all values are within this range, the tabulated value of MESG is that for which $(g_{100})_{\min} - (g_0)_{\min}$ is the smallest. For most substances, this difference will lie within one step of gap adjustment, i.e. within 0,02 mm.

If the difference between the values of $(g_0)_{\min}$ taken from different test series exceeds 0,04 mm, the laboratories concerned should repeat their tests after confirming that the test apparatus is able to reproduce the tabulated value for hydrogen. If the results are still not comparable, the reasons should be investigated by the laboratories working in collaboration.

6.4 Tabulated values

The values of the MESG $(g_0)_{\min}$, the difference $(g_{100})_{\min} - (g_0)_{\min}$, the most dangerous concentration and the test temperature are tabulated below in table 1. The value of the MESG is used to decide which group of flameproof enclosures should be used for electrical equipment and the value $(g_{100})_{\min} - (g_0)_{\min}$ indicates the accuracy of the tabulated value of the MESG.

Table 1 – Tabulated values

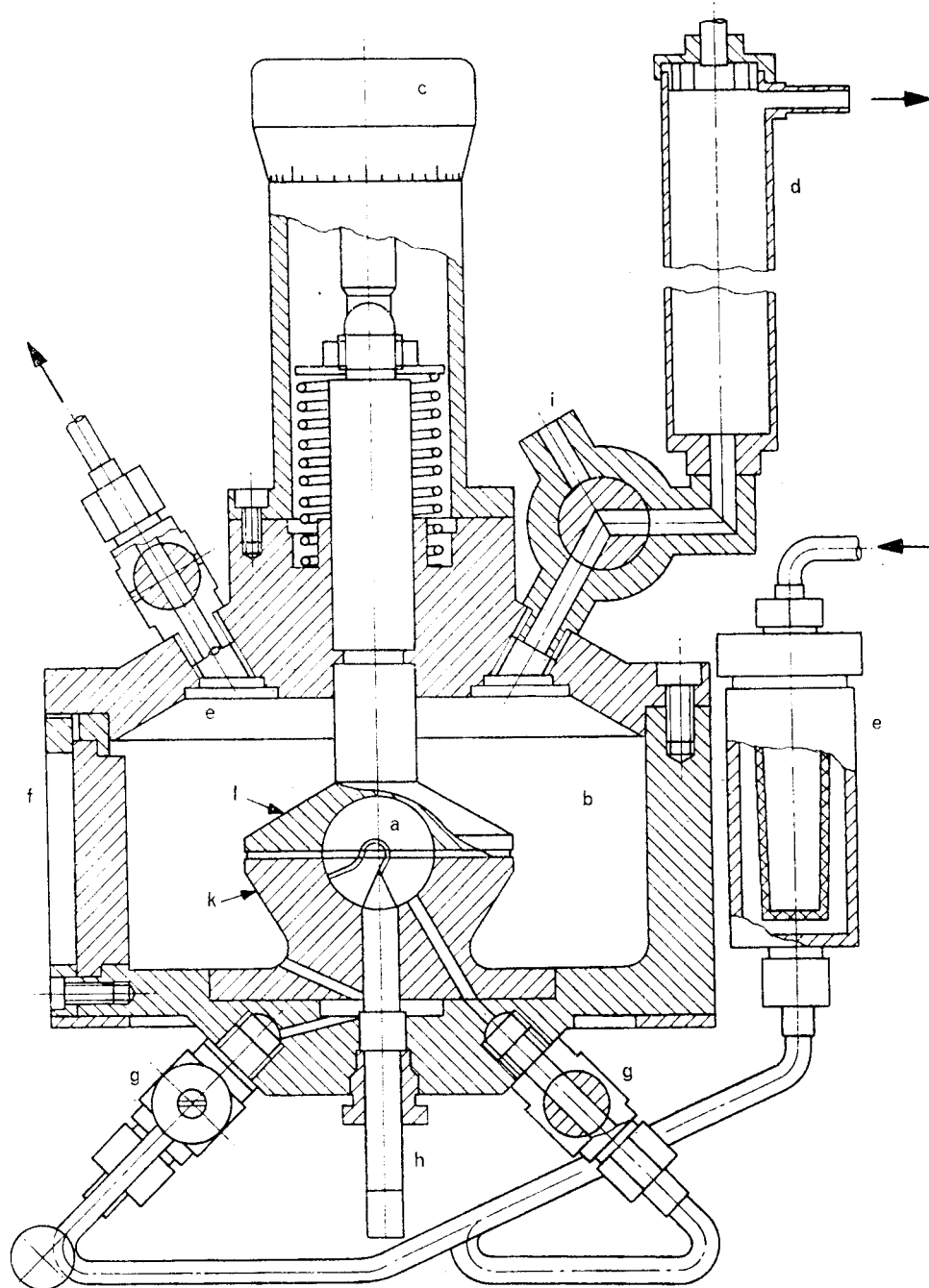
Inflammable gas or vapour		Most incensive mixture Volume %	MESG mm	$g_{100} - g_0$ mm
Carbon monoxide	CO	40,8	0,94	0,03
Methane	CH ₄	8,2	1,14	0,11
Propane	C ₃ H ₈	4,2	0,92	0,03
Butane	C ₄ H ₁₀	3,2	0,98	0,02
Pentane	C ₅ H ₁₂	2,55	0,93	0,02
Hexane	C ₆ H ₁₄	2,5	0,93	0,02
Heptane	C ₇ H ₁₆	2,3	0,91	0,02
Iso-octane	C ₈ H ₁₈	2,0	1,04	0,04
<i>n</i> -Octane	C ₇ H ₁₈	1,94	0,94	0,02
Decane	C ₁₀ H ₂₂	120/105 (mg/l)	[1,02]	–
Cyclohexanone	C ₆ H ₁₀ O	3,0	0,95	0,03
Acetone	C ₃ H ₆ O	5,9/4,5	[1,02]	–
Methyl ethyl ketone	C ₄ H ₈ O	4,8	0,92	0,02
Methyl acetate	C ₃ H ₆ O ₂	208/152 (mg/l)	[0,99]	–
Ethyl acetate	C ₄ H ₈ O ₂	4,7	0,99	0,04
<i>n</i> -Propyl acetate	C ₅ H ₁₀ O ₂	135 (mg/l)	[1,04]	–
Cyclohexane	C ₆ H ₁₂	90 (mg/l)	[0,94]	–
<i>n</i> -Butyl acetate	C ₆ H ₁₂ O ₂	130 (mg/l)	[1,02]	–
Amyl acetate	C ₇ H ₁₄ O ₂	110 (mg/l)	[0,99]	–
Vinyl Chloride	C ₂ H ₃ Cl	7,3	0,99	0,04
Methanol	CH ₃ OH	11,0	0,92	0,03
Ethanol	C ₂ H ₅ OH	6,5	0,89	0,02
Vinylidene chloride	C ₂ H ₂ Cl ₂	10,5	3,91	0,08
Phenyltrifluormethane	C ₆ H ₅ CF ₃	19,3	1,40	0,05
Isobutanol	C ₄ H ₁₀ O	105/125 (mg/l)	[0,96]	–
<i>n</i> -Butanol	C ₄ H ₁₀ O	115/125 (mg/l)	[0,94]	–
Pentanol	C ₅ H ₁₁ OH	100/100 (mg/l)	[0,99]	–
Ethyl nitride	C ₂ H ₅ ONO	270/270 (mg/l)	[0,96]	–
Ammonia	NH ₃	24,5/17,0	[3,17]	–
1,3-Butadiene	C ₄ H ₆	3,9	0,79	0,02
Ethylene	C ₂ H ₄	6,5	0,65	0,02
Diethyl ether	C ₄ H ₁₀ O	3,47	0,87	0,01

NOTE Values in square brackets, e.g. [0,96] are those obtained with the United Kingdom 8-litre sphere apparatus and not with the apparatus described in this standard. In these cases, the two gas concentrations quoted are the most incentive internal mixture and the most easily ignited external mixture.

All other values are obtained with the standard apparatus described in this standard, but in general with three tests per step of adjustment only.

Table 1 – Tabulated values (*continued*)

Inflammable gas or vapour		Most incentive mixture Volume %	MESG mm	$g_{100} - g_0$ mm
Ethylene oxide	C_2H_4O	~8	0,59	0,02
Town gas	H ₂ 57 % CO 16 %	~21/~21	[0,53]	–
Acetylene	C_2H_2	8,5	0,37	0,01
Hydrogen	H ₂	27	0,29	0,01
Carbon disulphide	CS ₂	8,5	0,34	0,02
Dioxane	$C_4H_8O_2$	4,75	0,70	0,02
Isopentane	C_5H_{12}	2,45	0,98	0,02
<i>n</i> -Butyl chloride	C_4H_9Cl	3,9	1,06	0,04
Di- <i>n</i> -Butyl ether	C_8H_{18}	2,6	0,86	0,02
Dimethyl ether	C_2H_6O	7,0	0,84	0,06
Propylene	C_3H_6	4,8	0,91	0,02
Acetonitrile	C_2H_3N	7,2	1,50	0,05
Di-isopropyl ether	$C_6H_{14}O$	2,6	0,94	0,06
1,2-Dichloroethane	$C_2H_4Cl_2$	9,5	1,80	0,05
Propylene oxide	C_3H_6O	4,55	0,70	0,03
Ethane	C_2H_6	5,9	0,91	0,02
Methyl isobutyl ketone	$C_6H_{12}O$	3,0	0,98	0,03
Acrylonitrile	$CH_2 = CHCN$	7,1	0,87	0,02
Methyl acrylate	$C_4H_6O_2$	5,6	0,85	0,02
Butylglycolate	$C_6H_{12}O_3$	4,2	0,88	0,02
2,4-Pentanedione	$C_5H_8O_2$	3,3	0,95	0,15
Hexanol	$C_6H_{13}OH$	3,0	0,94	0,06
Isopropanol	C_3H_7OH	5,1	0,99	0,02
Ethyl acrylate	$C_5H_8O_2$	4,3	0,86	0,04
Hydrocyanic acid	HCN	18,4	0,80	0,02
Vinyl acetate	$C_4H_6O_2$	4,75	0,94	0,02



Key

- | | |
|----------------------------------|-------------------------------|
| a interior chamber | g inlet valves |
| b exterior cylindrical enclosure | h spark electrode |
| c micrometer screw | i outlet port |
| d outlet port | k adjustable gap plate, lower |
| e flame arresters | l adjustable gap plate, upper |
| f observation windows | |

Figure 1 – Test apparatus

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Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards: Monthly Additions'.

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AMENDMENT NO. 1 DECEMBER 2006
TO
IS 9735 : 2003/IEC 60079-1-1 (2002) ELECTRICAL
APPARATUS FOR EXPLOSIVE GAS ATMOSPHERES —
FLAMEPROOF ENCLOSURES “d” — METHOD OF TEST
FOR ASCERTAINMENT OF MAXIMUM
EXPERIMENTAL SAFE GAP

(First Revision)

(Second cover, National Foreword, third para) — Add the following at the end:

‘IS 9735 : 1981 and IS 9735 : 2003 versions shall continue to run concurrently till 31 December 2007 after which IS 9735 : 1981 shall be deemed to be withdrawn.’

(ET 22)